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## CHAPTER 13

## DISINFECTION

13-1. General considerations. Disinfection is a process in which pathogenic organisms are destroyed or inactivated. Several methods have been utilized and include the following: (1) physical agents, (2) mechanical means, (3) radiation, and (4) chemical agents. Physical agents include heat (boiling) and light. Mechanical means include the removal of pathogens during wastewater treatment. Radiation utilizes gamma rays to sterilize wastewater. Chemical disinfection is the most commonly used method and will be used for mobilization work unless other methods outlined above become expedient or feasible.

13-2. Types of chemical disinfectants. Chemical disinfectants include (1) chlorine and its compounds, (2) bromine, (3) iodine, (4) ozone, (5) alcohols, and (6) various alkalies and acids. Discussion herein is limited to disinfection of wastewater treatment plant effluents by chlorine and its compounds since it is the most universally accepted disinfectant. Other chemicals as outlined above may be employed when chlorine is not available.

13-3. Design basis and criteria.

a. Chlorine forms. Chlorine is available as a liquid contained in cylinders or in the form of chlorine compounds such as calcium hypochlorite or sodium hypochlorite. These are the most commonly used compounds for disinfection. Liquid chlorine is evaporated and dissolved into the wastewater as a gas. Sodium hypochlorite is available in solution form, calcium hypochlorite is available in solid form.

b. Limitations on chlorine. Although chlorine is an effective disinfectant when in actual contact, the chlorine may not always come in contact with the microorganisms. Bacteria and viruses can hide (and often do) inside particles of suspended or colloidal matter. Therefore, chlorine disinfection will not guarantee removal of all health hazards from wastewater. Chlorine disinfection involves a very complex series of events and is influenced by the kind and extent of reactions with chlorine-reactive materials, temperature, pH, suspended solids concentrations, and the resiliency of some pathogenic organisms. Effective treatment will reduce the need for disinfection so proper design and operation of the treatment plant are essential. Nitrogen compounds in the wastewater affect chlorine dosages. Sufficient chlorine must be added to overcome their neutralizing effect.

c. Design parameters. For chlorination of wastewater treatment plant effluent, a detention period of 30 minutes in the contact chamber to provide maximum disinfection is required. Table 13-1 should be used to estimate chlorine dosage requirements.

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Table 13-1. Typical Chlorine Dosages Required for Sewage Disinfection

<u>Type of Effluent to be Disinfected</u>	<u>Dosage</u> mg/l	<u>Dosage</u> pounds/mil gallon
Raw Wastewater	20	167
Raw Wastewater (Septic)	50	417
Settled Wastewater	20	167
Settled Wastewater (Septic)	40	334
Trickling Filter Effluent	15	126
Activated Sludge Effluent	8	67

For the recommended treatment scheme presented in chapter 5, chlorine dosages of 15 mg/l or 126 pounds/mil gallon will be applied at average daily flows and a maximum of 27 mg/l or 226 pounds/mil gallon will be applied at peak daily flow rates, when disinfection is required. Sodium hypochlorite solution normally provides 12.5 percent available chlorine, and calcium hypochlorite solution normally provides 70 percent available chlorine. To determine the equivalent dosages required for these chemicals if used to disinfect the various types of effluents described above, divide the dosage figures by the fraction of available chlorine attributable to the specific chlorine compound. Chlorination of wastewater can reduce its BOD by 15 to 35 percent; this is a common practice to relieve overloaded plants until additional capacity is provided. Approximately 2 mg/l of BOD can be removed by 1 mg/l of chlorine up to the point at which residual chlorine is produced. Odor control can be achieved by prechlorination doses of 4 to 6 mg/l. Odors off sludge drying beds can be reduced by applying calcium hypochlorite at a rate of 1/2 pound per 100 square feet of bed area. Periodic application of chlorine to trickling filter influent will reduce filter clogging and ponding. A chlorine dose of 1 to 10 mg/l based on the returned sludge flow is sometimes required for control of bulking sludge in an activated sludge process. A chlorine residual of 1 mg/l in sludge thickener supernatant prevents sludge from becoming septic during its holding period.

d. Mixing. Rapid mixing at the point of chlorine application is critical for disinfection efficiency, while adequate mixing at the same point is critical for control purposes. The following methods are acceptable mixing practices to be used at Army installations: the hydraulic jump, submerged weir, the over and under baffle, the mechanical mixer, and the closed conduit flowing full and with adequate turbulence.

13-4. Chlorine feeding equipment. The chlorinator capacity will be designed to have a capacity adequate to provide the dosage requirement stipulated in paragraph 13-3.d. at maximum flow conditions. Design considerations will be based on the assumption that chlorine can be

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vaporized from 150-pound cylinders at a rate of 40 pounds per 24 hours, 30 pounds per 24 hours from 105-pound cylinders, and 450 pounds per 24 hours from 1-ton cylinders. Where greater rates of feed are required, a suitable number of containers will be manifolded, unless facilities are installed to prevent chlorine system freezing due to evaporation. The use of 1-ton cylinders will be used where the average daily chlorine consumption is over 150 pounds.

a. Direct feed chlorinator. The use of equipment for feeding chlorine gas from the cylinder through a control apparatus to the point of application is not permitted except under special conditions which prevent the use of solution-feed chlorinators.

b. Solution feed chlorinator. Pressure-feed type and vacuum-feed type are, in general, two types of solution feeders. The vacuum-feed type chlorinator is the preferred type and will be used for all installations where a suitable make-up water supply is available, such as potable water or suitable plant effluent.

c. Hypochlorite feeders. These feeders are of the mechanical positive-displacement metering type and their use will be limited to installations designed for the addition of hypochlorite solution.

d. Scales. Scales will be sized to accommodate the maximum number of cylinders required to serve the maximum chlorine rate. They may be mounted flush with the floor or on the floor surface within an enclosing box. With above-floor mounting, overhead hoist equipment must be considered. Flush-mounted scales will require drainage of the scale sump. A loss-of-weight recorder is desirable to provide a continuous record of chlorine feed.

e. Hoists. Electric hoisting equipment is recommended for installations using 1-ton cylinders. Hoists will have a minimum capacity of 2 tons and will be equipped with an approved type of lifting-beam container grab.

f. Piping. Only pipe and materials suitable for chlorine and chlorine solutions such as PVC plastic pipe, rubber-lined pipe, or materials otherwise acceptable by the manufacturers of chlorine equipment will be used in chlorine installations. Piping and valves will be identified as components of the chlorination system.

g. Housing.

(1) Room separation. If chlorinators and/or cylinders are in a building used for other purposes, a gas-tight partition will separate the chlorine room from any other portion of the building. Doors to the room will open only to the outside of the building and will be equipped with panic hardware. The storage area will be separated from the feed area.

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(2) Inspection window. A clear glass, gas-tight window will be installed in an exterior door or interior wall of the chlorinator room to permit the chlorinator to be viewed without entering the room.

(3) Heat. Chlorine equipment rooms will be provided with a means of heating so that a room temperature of at least 60 degrees F. can be maintained. This will help insure a continuous flow of gas from the chlorine cylinder and will help prevent the formation of chlorine hydrate in the chlorinator.

(4) Ventilation. Forced, mechanical ventilation, which will provide one complete air change every 3 minutes, will be installed. The entrance to the air exhaust duct from the room will be near the floor, and the point of discharge will be so located as not to contaminate the air inlet to any building or inhabited areas. Air inlets will be so located as to provide cross-ventilation. To prevent a fan from developing a vacuum in the room, thereby making it difficult to open the doors, louvers should be provided above the entrance door and opposite the fan suction. Where duct work is required to carry air to the fan, it should be laid out so that the suction openings are at floor level and spaced so as to exhaust air from all equipment areas. Exhaust openings should be designed so that covers are not required.

(5) Electrical controls. A common control for the fans and lights keyed to an exterior lock on the entrance door will be installed so that they will automatically come on when the door is opening, will only be deactivated by relocking the door externally, and can also be manually operated from the outside without opening the door.

(6) Cylinder storage. A storage area will be provided to allow for a minimum 15-day inventory of reserve and empty containers. Cylinders may be stored outdoors on suitable platforms at or above grade and under cover of a well-ventilated fireproof structure.

(7) Precautions in the use of chlorine. The presence of chlorine gas in the atmosphere can pose immediate and serious hazards to the health of any person breathing the air. Gas masks approved by the National Institute for Occupational Safety and Health (NIOSH) will be provided outside any area where an individual would be exposed in the event of chlorine leaks, spills, etc. All rooms in which chlorine is to be stored or handled should be adequately ventilated to the outside. A fan automatically turned on prior to entry into the chlorination or storage facility will be provided. Since chlorine gas is heavier than air, vent outlets will be placed at floor level. Chlorine detectors of the electronic, solid state type, sensitive to one part per million chlorine (by volume) in air, that continuously monitor the air for chlorine will be installed to provide a visual/audible alarm in the event of a chlorine leak. Alternatively, the enclosed space should be entered only if the worker is under observation by a co-worker and if the worker has in his possession a

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respirator suitable for escape. The applicable safety recommendations as given in AWWA Manual No. 3 and WPCF Manual of Practice No. 1 should be followed. Information on the properties of chlorine and its safe handling are also available in the CI Chlorine Manual. When hypochlorite compounds are used, the above requirements do not apply.

13-5. Chlorine contact chambers. A chlorine mixing contact chamber will be designed to provide a minimum of 30 minutes detention time at the average design flow. Consideration will be given to two flow-through units with common wall construction so that their total volume satisfies detention requirements, to allow for periodic cleaning. Minimize short-circuiting with inlet baffles and end-around baffling within the tank. The chlorine feed rate will be proportioned in accordance with the flow and the chlorine demand of the wastewater. Adequate mixing during the chlorine contact period will be insured by the installation of adequate baffling, or by mechanical mixing equipment.

13-6. Residual limitations. Residual chlorine in the plant effluent must be kept to just below 1.0 mg/l.